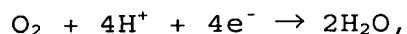


## CLAIMS

1. A catalyst comprised of a material which contains carbon and nitrogen and in which the presence ratio of carbon relating to a shake-up process is controlled.

2. The catalyst as set forth in claim 1, which is an oxygen reduction catalyst for accelerating an oxygen-reducing reaction of the following formula:



which contains carbon and nitrogen as indispensable component elements, and in which the presence ratio of carbon relative to the shake-up process in the surface thereof is controlled.

3. A catalyst comprised of activated carbon so controlled that, in measurement of electron spin resonance, first unpaired electrons with a g value of 1.9930 to 2.0000 are contained in a spin density of not less than  $3.1 \times 10^{19}/\text{g}$ , and second unpaired electrons with a g value of 2.0020 to 2.0026 are contained in a spin density of not less than  $6.0 \times 10^{14}/\text{g}$ .

4. The catalyst as set forth in claim 3, wherein in said measurement of electron spin resonance, said first unpaired electrons show Pauli paramagnetism, and said second unpaired electrons show Curie paramagnetism.

5. The catalyst as set forth in claim 1 or 2, containing nitrogen atoms in an amount, in terms of atom number percentage in the surface thereof, of not less than 0.96 mol%.

6. The catalyst as set forth in claim 1 or 2, having at least one species of first nitrogen atoms having an N1s electron bonding energy of  $398.5 \pm 0.5$  eV, second nitrogen atoms having an N1s electron bonding energy of  $401 \pm 0.5$  eV, and third nitrogen atoms having an N1s electron bonding energy of  $403.5 \pm 0.5$  eV.

7. The catalyst as set forth in claim 6, containing, in terms of atom number percentage in the surface thereof, said first nitrogen atoms in an amount of not less than 0.22 mol%, said second nitrogen atoms in an amount of not less than 0.53 mol%, and said third nitrogen atoms in an amount of not less than 0.21 mol%.

8. A method of producing a catalyst, comprising the steps of baking a material containing carbon and nitrogen as component elements, and subjecting the resulting baked product to steam activation, wherein the presence ratio of carbon relating to a shake-up process and/or the spin density of first unpaired electrons with a g value of 1.9930 to 2.0000 and the spin density of second unpaired electrons with a g value of 2.0020 to

2.0026 are controlled.

9. A method of producing a catalyst as set forth in claim 8, wherein a mixture powder of a carbonaceous solid raw material and a nitrogen-containing organic compound or a nitrogen-containing organic polymer powder is baked, and the resulting nitrogen-containing carbide powder is subjected to steam activation, whereby an oxygen reduction catalyst comprised of a nitrogen-containing activated carbide is produced.

10. A method of producing a catalyst as set forth in claim 8, wherein said control is carried out by regulating the temperature of said baking.

11. A method of producing a catalyst as set forth in claim 9, wherein said control is carried out by regulating the mixing ratio of said carbonaceous solid raw material and said nitrogen-containing organic compound.

12. A method of producing a catalyst as set forth in claim 9, wherein said control is carried out by selection of said nitrogen-containing organic polymer compound material to be used.

13. A method of producing a catalyst as set forth in claim 9, wherein coal-derived binder pitch is used as said carbonaceous solid raw material.

14. A method of producing a catalyst as set forth in claim 9, wherein melamine or hydrazine is used as said nitrogen-containing organic compound.

15. A method of producing a catalyst as set forth in claim 9, wherein polyacrylonitrile, a melamine resin, nylon, gelatin, or collagen is used as said nitrogen-containing organic polymer compound.

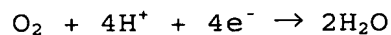
16. A method of producing a catalyst as set forth in claim 8, wherein said baking and said steam activation is carried out in a high-purity nitrogen stream at a temperature of 1000°C.

17. An electrochemical device comprising a plurality of electrodes, and an ion conductor clamped between said plurality of electrodes, wherein at least one of said plurality of electrodes contains a catalyst as set forth in any of claims 1 to 7.

18. The electrochemical device as set forth in claim 17, configured as a fuel cell.

19. The electrochemical device as set forth in claim 18, wherein said catalyst is contained as an oxygen electrode catalyst.

20. A catalyst containing a nitrogen-containing carbonaceous catalyst for accelerating an oxygen-reducing reaction of the following formula:



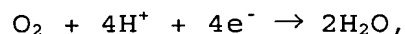
and a hydrogen ion conductive polymer material.

21. The catalyst as set forth in claim 20, wherein said hydrogen ion conductive polymer is a perfluorosulfonic acid resin.

22. The catalyst as set forth in claim 21, wherein the mixing ratio of said perfluorosulfonic acid resin is from 5 to 30 mass%.

23. The catalyst as set forth in claim 20, wherein the mass of said nitrogen-containing carbonaceous catalyst per unit area is from 10 to 110 mg/cm<sup>2</sup>.

24. A catalyst electrode formed by pressurizing and/or heating from a powdery mixture containing a nitrogen-containing carbonaceous catalyst for accelerating an oxygen-reducing reaction of the following formula:



and/or a conductive material carrying said catalyst thereon, and a hydrogen ion conductive polymer material.

25. The catalyst electrode as set forth in claim 24, formed from said powdery mixture of said nitrogen-containing carbonaceous catalyst, said hydrogen ion conductive polymer material, and a conductive material.

26. The catalyst electrode as set forth in claim

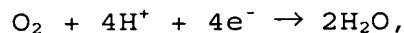
24, formed under a forming pressure in the range of 2.8 to 39.6 kN/cm<sup>2</sup>.

27. The catalyst electrode as set forth in claim 24, wherein said hydrogen ion conductive polymer is a perfluorosulfonic acid resin.

28. The catalyst electrode as set forth in claim 27, wherein the mixing ratio of said perfluorosulfonic acid resin is from 5 to 30 mass%.

29. The catalyst electrode as set forth in claim 24, wherein the mass of said nitrogen-containing carbonaceous catalyst per unit area is from 10 to 110 mg/cm<sup>2</sup>.

30. A method of producing a catalyst electrode, comprising the steps of preparing a powdery mixture containing a nitrogen-containing carbonaceous catalyst for accelerating an oxygen-reducing reaction of the following formula:



and/or a conductive material carrying said catalyst thereon, and a hydrogen ion conductive polymer material, and forming said powdery mixture by pressurizing and/or heating.

31. A method of producing a catalyst electrode as set forth in claim 30, comprising the steps of preparing

said powdery mixture of said nitrogen-containing carbonaceous catalyst, said hydrogen ion conductive polymer material, and a conductive material, and forming said powdery mixture.

32. A method of producing a catalyst electrode as set forth in claim 30, wherein said forming is conducted under a pressure in the range of 2.8 to 39.6 kN/cm<sup>2</sup>.

33. A method of producing a catalyst electrode as set forth in claim 30, wherein a perfluorosulfonic acid resin is used as said hydrogen ion conductive polymer.

34. A method of producing a catalyst electrode as set forth in claim 33, wherein the mixing ratio of said perfluorosulfonic acid resin is from 5 to 30 mass%.

35. A membrane-electrode assembly wherein a catalyst electrode as set forth in any one of claims 24 to 29 is joined to a hydrogen ion conductive membrane.

36. The membrane-electrode assembly as set forth in claim 35, wherein said hydrogen ion conductive membrane is clamped between said catalyst electrode and a hydrogen electrode.

37. An electrochemical device wherein a membrane-electrode assembly as set forth in claim 35 is used for an electrochemical reaction part.

38. The electrochemical device as set forth in

claim 37, configured as a cell.

39. The electrochemical device as set forth in  
claim 38, wherein said cell is a fuel cell.